(12) UK Patent Application (19) GB (11) 2 321 814 (13) A

(43) Date of A Publication 05.08.1998

(21) Application No 9701638.0

(22) Date of Filing 28.01.1997

(71) Applicant(s)
British Broadcasting Corporation
(Incorporated in the United Kingdom)
Broadcasting House, LONDON, W1A 1AA,
United Kingdom

(72) Inventor(s)
Graham Alexander Thomas

(74) Agent and/or Address for Service
Mathys & Squire
100 Grays Inn Road, LONDON, WC1X 8AL,
United Kingdom

(51) INT CL^{6}
H04N 5/275, G02B 5/128

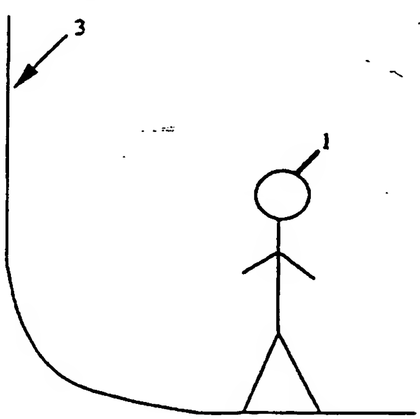
(52) UK CL (Edition P)
H4F FD2A FD27R1 FGJ
G2J JMR1

(56) Documents Cited
GB 2297613 A GB 2162628 A EP 0209317 A2
US 4471386 A

(58) Field of Search
UK CL (Edition O) H4F FGJ FGS FGT
INT CL^{6} H04N 5/272 5/275 9/75
Online: WPI,INSPEC

(54) Abstract Title
Key signal generation using retro-reflective background in video image composition system

(57) A subject 1 is imaged in front of a retro-reflective background 3 and light projected from the camera 5, preferably from a ring of key-coloured LEDs 7 disposed around the camera lens, is used to generate a key signal for distinguishing the subject from the background so that the subject may be keyed into a separate background image 11. Instead of projecting a key colour on to the retro-reflective background a pattern or brightness property of the projected light may be used as the keying signal. Alternatively the projected light may vary in time with respect to brightness and/or colour and the resulting temporal characteristic used as the keying signal. A shadow effect may be produced by illuminating the subject from another direction to that of the LEDs 7. The retro-reflective material comprises a flexible material coated with randomly orientated retro-reflective particles (Figs 3 and 5).



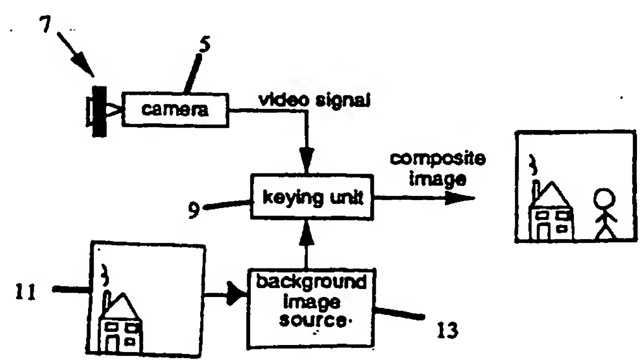


Fig. 2

GB 2 321 814 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

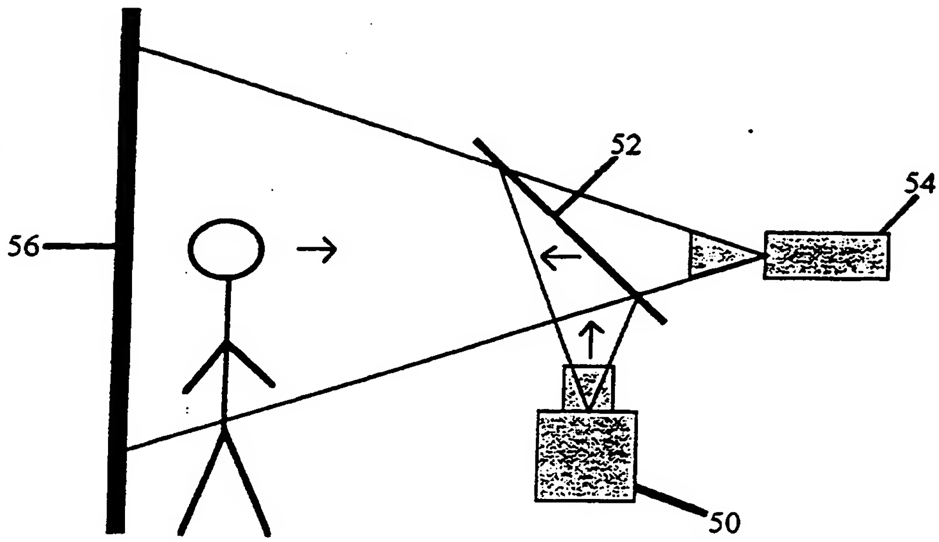


Fig. 1

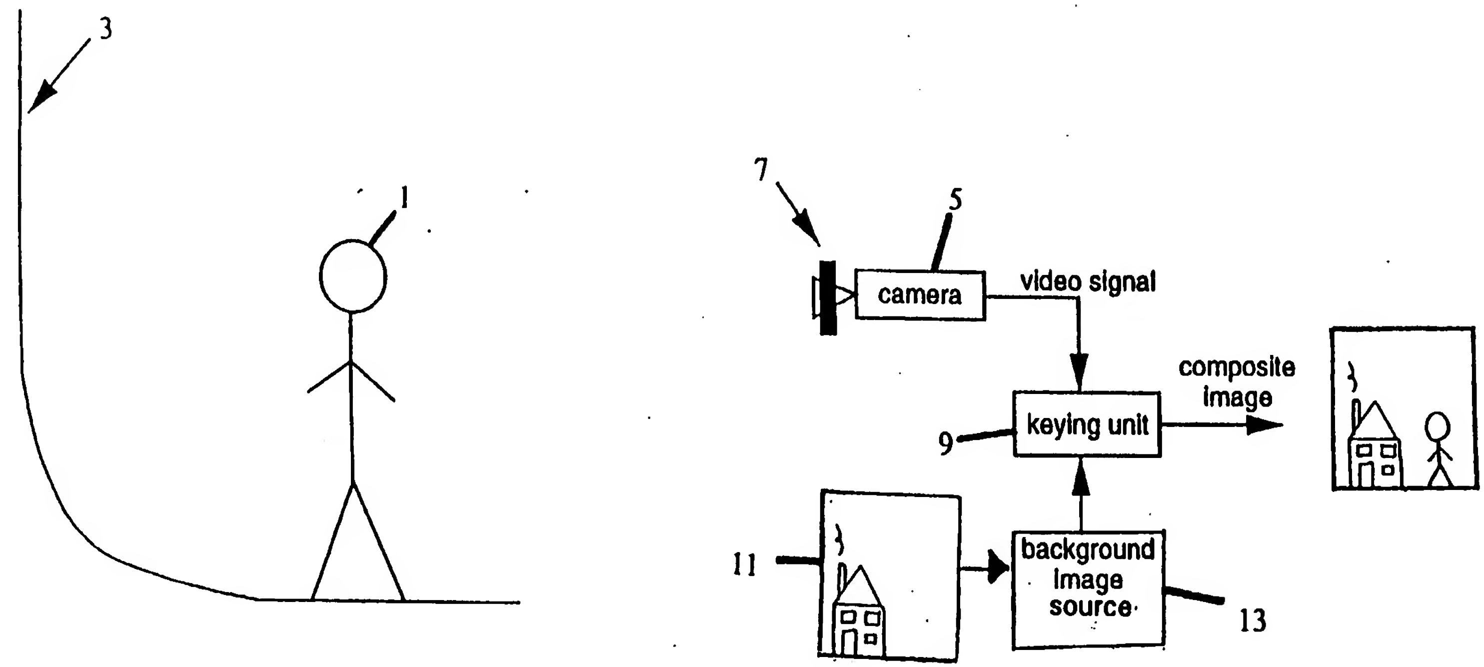

3
1
7
5
camera
video signal
composite
image
keying unit
9
11
background
image
source
13

Fig. 2

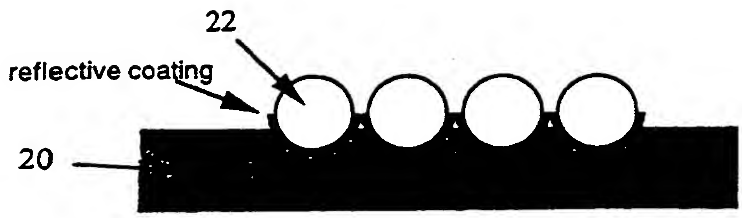


Fig. 3a

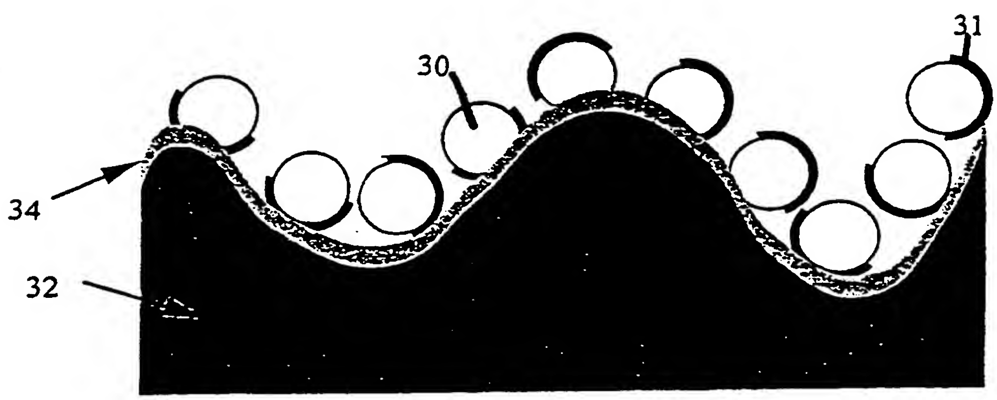


Fig. 3b

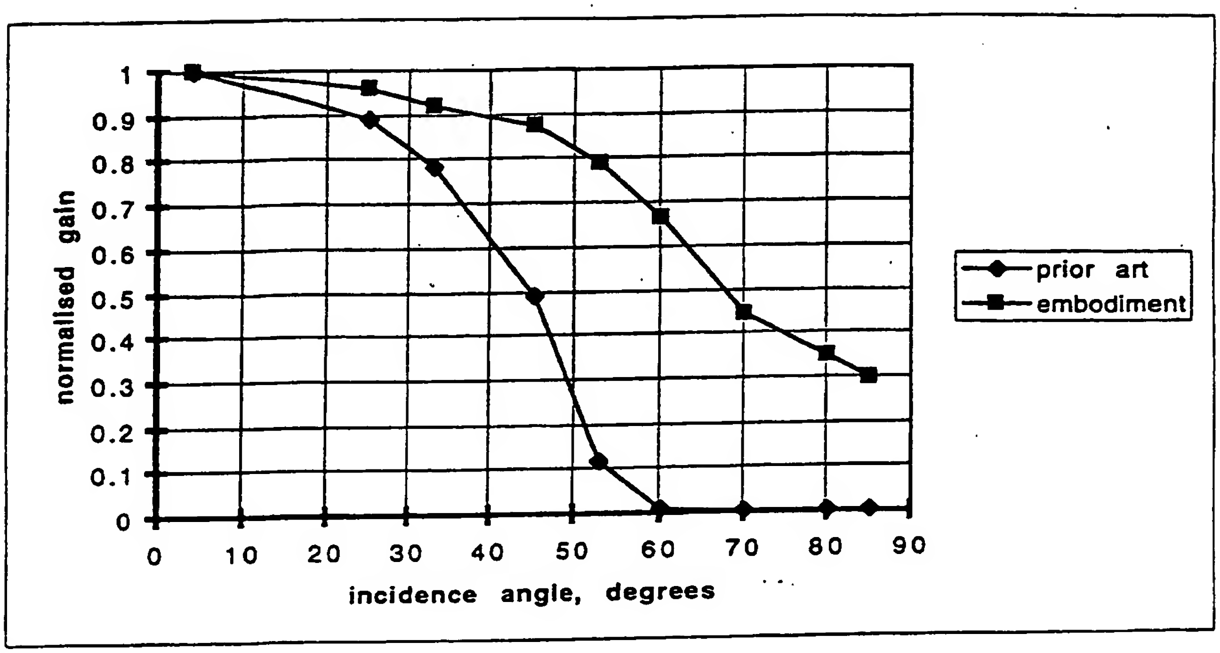

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
normalised gain
0
10
20
30
40
50
60
70
80
90
incidence angle, degrees
prior art
embodiment

Fig. 4

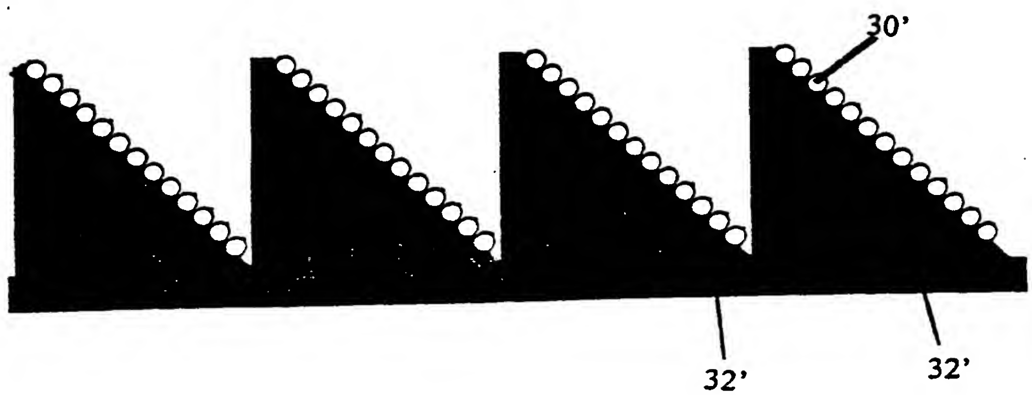


Fig. 5

2321814

VIDEO IMAGING

The present invention relates generally to video imaging, and more specifically to video imaging in which a foreground image can readily be distinguished from a background, for example as used to superimpose foreground detail filmed at one location onto a separate background. It is well known to superimpose a foreground image, for example of an actor or presenter, filmed in a studio, onto a background which has been filmed elsewhere, or is computer-generated.

Conventionally, this is achieved by a technique known as chroma-keying, in which the foreground subject is filmed against a background of a uniform "key" colour (typically blue), and a "key" signal generated electronically from the chrominance output of a camera is used to trigger the switch between the foreground image generated from the camera and a separate background image.

This technique has been widely used. However, in order to generate a good key signal with low noise, it is necessary to have the coloured background illuminated brightly and evenly. This can give rise to several problems, particularly when used in large studios. Providing uniform illumination for a large area of blue is difficult and time-consuming to set up. In addition, it often becomes difficult to light the actors to give the desired artistic effect, since the lighting is primarily determined by the requirement to provide bright and even illumination for the background to provide reliable keying. Typically 20kW of tungsten lighting may be required for a set. This consumes significant amounts of electricity, both directly and in the need for extra air-conditioning to remove the excess heat generated. Even with lighting devoted to the background, on many sets, some areas where dark shadows cannot be avoided, such as under tables, will remain, and these do not produce clean key signals. Coloured light scattered from the brightly-lit background and floor can fall onto actors and props, changing their hue and

giving an unnatural appearance. These problems normally lead to increased production costs, and can result in deterioration in the quality of the final production.

An alternative method for superimposing foreground detail onto a background is to project an image of a desired background from a point substantially optically coincident with the camera onto a retro-reflective screen located behind the foreground subject. A typical conventional arrangement for achieving this, in which a projector 50 projects an image via a semi-reflecting mirror 52 in front of the camera 54 onto a retroreflective screen 56 is depicted in Fig. 1. Although the image will also be projected onto actors in front of the screen, the projected image is so dim that it is not normally visible. The screen behind the actors will not be illuminated by the projector since the actors block the path of the projected light (they cast a shadow) but this does not matter so long as the projector is effectively coincident with the camera since the shadow area will not be visible.

This method allows actors to appear to be in front of a chosen background scene without the need for any subsequent manipulation of the image such as that required by the chroma-key process described above. However, the image quality of the background image may be poor, since it is subject to a projection process. This can lead to the image appearing de-focussed. In addition, the relative brightness, black level and colorimetry of the foreground and background images can only be controlled crudely, by adjusting the light level of the projector for example. Once the recording has been made, no further adjustment is possible. Furthermore, the technique does not provide electronic identification of the foreground subject for subsequent processing, and can only be used to generate superimposed images. Thus it cannot be used in "virtual studio" applications where the camera is allowed to move and the background scene is generated or manipulated accordingly to maintain the correct registration. This is because there is an inherent time delay in measuring camera motion and manipulating

the background image, so the background image could not be generated in time to keep up with the camera movement.

The present invention seeks to alleviate some or all of the drawbacks associated with the above mentioned prior art techniques.

According to a first aspect, the present invention provides an imaging method comprising:

positioning a subject to be imaged between a retro-reflective background and camera means for acquiring an image of the subject;

illuminating at least the background within the field of view of the camera means from substantially the same direction as the camera so that light of a predetermined property is reflected to the camera;

processing the output of the camera to distinguish the subject from the background based on detection of the predetermined property.

An advantage of this is that the background is illuminated relatively uniformly and from the same direction as the camera, so the problem of shadows is alleviated; every portion of the background that the camera "sees" should be illuminated. In addition, since a high proportion of the incident light can be reflected back to the camera, illumination of a lower intensity, and which is directed over a smaller area, can be used; thus interference with other set lighting can be reduced compared to prior art arrangements.

Moreover, the use of a retro-reflective material may allow a wider choice of property to be used to generate keying. Detection may be based on a single characteristic (for example colour) or a combination of characteristics (for example colour, brightness, temporal dependence), and the term "property" is used herein to include both single and multiple characteristics.

Because a much higher proportion of the light is reflected than with a conventional background, it may be possible to distinguish the background

based on the brightness of the image; this may be used alone, or in combination with detection of a particular colour or pattern. The use of brightness to generate keying has not been proposed before, and this represents a further aspect of the invention.

In addition, the inventor has found that temporally varying illumination may be used readily to generate keying, for example illumination which flashes on and off, or changes colour; this is provided in a further aspect of the invention.

A predetermined pattern may be used, preferably a repeating pattern with a high spatial frequency, (for example a chequerboard) and detected, for example, by detection of spatial frequency or image processing. However, it is preferred to use colour for keying; this enables conventional chroma-keying apparatus to be used.

In a preferred arrangement, light of a predetermined "key" colour is projected onto the background, the background preferably being retroreflective for a variety of colours. This has the advantage that the "key" colour can be changed simply by changing the colour of light projected, without needing to change the set.

In another arrangement, the retro-reflective background is coloured and or patterned, for example to reflect back light of a "key" colour. This has the benefit that it may be used with a projector of white light, and will reflect light of the correct colour even when other studio lights cause light to be reflected to the camera; this is useful because a practical retro-reflective material does not reflect 100% of incident light back to the source. Such a retroreflective material may be used with coloured light or with white light as the source associated with the camera.

Preferably, the method further comprises superimposing the image of

the subject onto a further background image. This may be used to produce a composite image substantially free of the problems identified with the prior art superposition methods.

In one preferred arrangement, the background is illuminated by projecting light of the desired key colour through a partially-reflective mirror disposed between the subject and the camera. This has the advantage that the source of light can be made very nearly optically coincident with the camera. This may provide optimum retro-reflective effect, and may alleviate problems encountered in the prior art around edges of objects, due to shadows falling on the background.

In a further arrangement, the light is projected through at least one lens of the camera used to form the image. This has the advantage that the light source may be more nearly optically coincident with the camera axis, and further that the area illuminated by the light source may be automatically made coincident with the area illuminated by the camera.

In an alternative preferred arrangement, the background is illuminated by at least one and preferably a plurality of light sources disposed around or adjacent to the camera lens. Although the light sources need not be exactly coincident with the camera axis, they should be positioned so that sufficient light is reflected slightly off-axis into the camera to ensure adequate illumination. This arrangement may have the benefit of being simpler to implement. In addition, light is projected directly, so there may be less losses and a lower intensity light source may be used. If the illumination is positioned in a relatively narrow ring around the camera, this should ensure that substantially no shadows are visible by the camera.

The exact arrangement will depend on the retro-reflective material used and the spread of angles over which it reflects incident light, but preferably the light source(s) and the camera axis subtend an angle of less than about 5

degrees and more preferably of the order of about 1 degree over a major portion of the background. The more nearly coincident, the more effective should be the reflection back to the camera.

In a related aspect, the invention provides a method of providing a subject for imaging comprising providing a subject between a substantially retro-reflective background and a camera having, substantially coincident with optical axis thereof, a source of illumination of a predetermined key colour for illuminating said background.

In a further aspect, the invention provides apparatus for imaging a subject, the apparatus comprising:

camera means for obtaining an image of the subject;

retro-reflector means for positioning behind the subject, as seen by the camera, for reflecting light originating substantially coincident with the camera back to the camera;

illuminating means associated with the camera means and arranged to project light onto at least said reflector means within the field of view of the camera means to reflect light of a predetermined colour or pattern back to the camera means.

The apparatus preferably further comprises processing means arranged to process the image to distinguish the subject from the background based on detection of the predetermined colour or pattern.

Preferred features of the method aspect may be applied to the apparatus aspect.

Preferably, the retro-reflector means comprises a substantially flexible retro-reflective material. This enables the retro-reflective material to be draped over backgrounds which are not necessarily of a regular shape. References to retro-reflective material in this specification imply a material, preferably in

sheet form, of which at least a predetermined portion of one side exhibits substantial retro-reflectivity.

Preferably, the retro-reflector means covers both a substantially vertical portion and a substantially horizontal portion of the background. This may allow the camera to be moved over a wider area and still obtain satisfactory reflection from the background.

Development of prior art retro-reflective materials has generally been concerned with maximising absolute retro-reflectivity. This has been quite successful, and materials with a peak gain (ratio of reflected light intensity at normal incidence compared to an ideal white surface which scatters light uniformly) of 500-1000 are now commercially available. However, the inventor has discovered a problem that such materials tend to have much lower reflectance at large angles of incidence, and for a typical material, the retro-reflectance is reduced by a factor of about 10 at an incidence angle of about 50 degrees, and is barely measurable at incidence angles of 60 degrees and above. Surprisingly, it has been found that a decrease in absolute retro-reflectivity can be tolerated if the retro-reflectivity characteristics are made more uniform.

Thus, in a further aspect, the invention provides a retro-reflective material having a normalised gain of at least about 1/4 for incidence angles up to at least 60 degrees, more preferably at least 70 degrees or 80 degrees. Preferably, the normalised gain at these angles is at least about 1/3, and preferably, at least for angles up to 60 degrees, the normalised gain is at least about 1/2.

Preferably, the material comprises retro-reflective particles, for example substantially spherical beads or corner-cube prisms, disposed (coated) substantially randomly orientated on a backing material, preferably having a rough surface, preferably cloth. By rough surface is meant a surface that has

undulations, recesses or projections of size at least comparable to the particles. The random orientation allows the material to be relatively uniformly reflective over a range of entrance angles. In addition, the provision of a rough surface increases the reflectivity of the material at entrance angles which are nearly parallel to the surface, as a proportion of the particles will be exposed more fully than if all particles were flush against a uniform surface.

Preferably, the particles are bonded to the backing with an adhesive material located substantially between the particles and the backing. This may offer better performance than conventional materials in which the particles are substantially embedded in an adhesive layer.

In one preferred arrangement, the backing material is substantially black. This minimises unwanted reflections from the backing material, or unwanted introduction of colour other than the key colour projected by the light source. In another preferred arrangement, the backing material has a colour substantially the same as that of the intended key colour. With this arrangement, the material will continue to reflect light of the desired colour even if some of the retro-reflective particles are displaced, for example when the material becomes worn. In addition, other set lighting, for example white light incident from other directions will be reflected as the key colour.

Preferably, the size of the individual retro-reflective particles is less than the resolution of the camera, preferably less than 1mm, and preferably of the order of tens or hundreds of microns.

In a further development, it has been found that it is not always desirable for the retro-reflective material to have uniform retro-reflective properties, or a peak gain at normal incidence. On the contrary, particulary on set floors, it is desirable for the peak gain to be in a direction angled generally towards the camera.

Thus, in a further aspect, the invention provides a flexible retro-reflective sheet material having a maximum gain at an angle of incidence substantially distinct from normal incidence, preferably at least about 30 degrees, and more preferably about 45 degrees to normal incidence, or greater. This may allow greater reflectivity to be obtained at larger angles of incidence, and in a direction where the reflectivity is needed.

It will be appreciated that a given angle of incidence defines a cone of possible incident directions. Conventional materials typically aim to present substantially uniform reflectivity for all directions. It has been appreciated that when the retro-reflective material is applied to a studio set, particularly on the floor thereof, many of these directions will correspond to camera positions which will not be used. Therefore, it has been proposed to provide an assymetrical gain profile, in which gain is reduced in certain directions, but gain or range of available incidence angles is increased in other direction.

In a closely related further aspect, the invention provides a flexible retro-reflective sheet material wherein the gain at a predetermined angle of incidence, measured from a first direction, is substantially greater than the gain at the same angle of incidence, measured from a second direction. Such a material may be positioned with the first direction generally directed towards the camera.

As discussed above, the generation of a key signal is useful in the superposition of a primary image onto a separate background. The areas of the primary image which generate the key signal may not be discarded entirely, but some information may be extracted, particularly to generate shadows so that the composite image seems more realistic. This may be done either by detecting the luminance of the key signal, or the "quality" of the key signal (that is, the closeness of the detected hue to the predetermined hue for the key signal), a better quality key signal being obtained in areas of brighter illumination, and a poorer quality signal indicating areas of shadow.

Surprisingly, it has been found that when retro-reflective material is used to generate a key signal as aforementioned, the quality of the key signal may be improved in areas of poor illumination (for example shadows); this is presumed to be because less extraneous light mixes with the pure colour projected onto the background.

This surprising finding is made use of in another aspect of the invention which provides an imaging method comprising:

positioning a subject to be imaged between a retro-reflective background and camera means for acquiring an image of the subject;

illuminating at least the background within the field of view of the camera means from substantially the same direction as the camera so that light of a predetermined key colour or pattern, preferably colour, is reflected to the camera;

illuminating at least a portion of the subject from another direction, thereby to create a shadow on a portion of the background;

processing the output of the camera to distinguish the subject from the background based on detection of the predetermined key colour or pattern, wherein a measure of quality of key detection is determined based on the correlation between the output of the camera and the predetermined colour or pattern, and wherein the shadow portion is identified as corresponding to an area of the image in which the quality of key detection is greater than in surrounding areas of the image.

In a further aspect, the invention provides image processing apparatus comprising:

means for inputting an image;

means for determining a measure of the presence of a key colour or pattern, preferably colour, in portions of the image, and detecting background regions of the image based on regions where the measure is above a threshold value; and

means arranged to identify background regions having a greater value

of said measure as regions of shadow.

Identification of the shadow regions may comprise either "intelligent" identification, in which the regions are positively defined by image recognition algorithms. More simply, passive identification, in which images are combined in such a way (by addition, subtraction, multiplication) that a corresponding similar shadow appears in resulting the composite image may be used. This can use similar processing to that used for conventionally generated key signal, but in which the sense in which the "quality" of the key signal is inverted in its application to generation of shadows.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

Fig. 1 shows a prior art arrangement in which a background image is projected onto a screen behind the subject;

Fig. 2 shows a schematic diagram of an embodiment of the invention;

Fig. 3a shows the construction of conventional retro-reflective material;

Fig. 3b shows retro-reflective material according to an embodiment of the invention;

Fig. 4 shows a comparison of the reflective properties of conventional retro-reflective material and retro-reflective material according to the invention; and

Fig. 5 shows a further embodiment of a retro-reflective material according tothe invention, having an assymetrical gain pattern.

Referring to Fig. 2, a subject 1 is positioned in front of a background comprising a retro-reflective cloth 3 in the field of view of a camera 5. In this specification, references to retro-reflective imply the property of reflecting a substantial portion of incident light back to the source over a range of incidence angles, and in particular reflecting a substantially greater intensity of incident light to the source than an ideal white background. The magnitude

of the range of incidence angles may vary, but the term is intended to exclude the infinitessimal range of angles over which a conventional planar mirror returns light to the source. A light source 7 comprising a ring of lights of a chosen key colour, in this embodiment provided by six blue high-intensity light-emitting diodes each producing an output of about 200mcd, is disposed around the camera lens and projects light towards the subject. Other light sources may be used, but LEDs offer the advantage of being small and lightweight, consuming litle power, and producing little heat. Very surprisingly, LEDs consuming a few milliwatts of power can, with the invention, produce as effective keying as conventional methods requiring 20kW of light. The light source preferably has a power of less than about 1kW, more preferably less than about 100W, most preferably no more than a few watts; this facilitates positioning close to the camera without excessive problems of heat dissipation. The output of the camera, a video signal comprising chrominance and luminance information, is passed to a chroma-key unit 9 which identifies the subject based on the colour of the image and overlays a separate background image 11 from a further video source 13 onto the background portions of the image. This results in a composite image output in which the subject 1 appears to be positioned on the separate background image 11.

The construction of the chroma-key unit is not germane to this aspect of the invention, and may be a conventional chroma-key unit. As will be appreciated, although it is convenient to use chrominance and luminance signals, other output signals (for example RGB) could be used, and detection of the background can be implemented by hardware and/or software.

A modified chroma-keying unit for use with the invention will now be described. A conventional chroma-keying unit may be considered in simple terms as producing an output image whose intensity corresponds to the quality of the key signal, or degree of correlation of the input image hue to a predetermined value. Maximum intensity in a conventional unit normally corresponds to an area in the image producing a clean key signal, and areas

of shadow from a conventional set will have slightly lower intensity, the degree to which the intensity decreases typically being adjustable. This intensity variation can be used to modulate the brightness of an image on which the input image is superimposed, to result in the appearance of shadows. In the modified chroma-key unit, the sense of the intensity variation is inverted before undergoing analogous processing to result in shadows in the output image. That is, the image is processed so that areas of maximum intensity appear as shadows, and areas of slightly lower intensity appear as unshaded background.

In the embodiment shown, the subject signal is overlaid onto the background image in real time by the chroma-key unit, but it will be apparent that the image captured by the camera can be processed subsequently, and can be used for purposes other than constructing composite images; the image can be used in any application in which a subject needs to be distinguished from a background. For example, the invention can be applied to other fields where image recognition or movement detection would be enhanced or simplified by provision of a reliable means for distinguishing a subject from a background.

Blue is a preferred colour for use as the key colour, since this is typically not present in most conventional subjects, but other colours may be used. In particular, the "colour" need not necessarily be a visible colour, but could, for example, comprise a near infra-red or near ultra-violet wavelength, provided the camera means and keying unit together are able to identify the "colour". Although it is preferable for the same camera that is used to capture the subject to be used to detect the key colour, it is possible for separate camera units to be provided within the camera means for detection of the subject and for detection of key signal. Construction of a composite colour camera which has separate tubes for each of three colours is well known; this construction principle could be applied to a camera which includes a detector specifically for the key signal. Such a technique may be applied where the subject contains a broad spectrum of visible colours, limiting the choice of

visible key colour.

In the embodiment shown in Fig. 2, the light source is disposed around the camera lens. However, in an alternative development, an arrangement similar to that depicted in Fig. 1 may be used, in which a light source projecting the key colour is used in place of the projector 50. This has the benefit of improved alignment of the light source and camera but may increase the complexity of the system.

In a further arrangement, the light source is integrated into the camera, so that the light is projected through at least one, and preferably all image-forming lenses of the camera. This may be achieved, for example, by placing a semi-reflective mirror between the final lens and the image-forming element of the camera. Alternatively, a light source, preferably comprising one or more light-emitting diodes may be disposed around the camera iris. This has the benefit that the light source itself should not be imaged by the camera. Placing the light source in the focal plane has the advantage that the light source should not cast an image onto the image-forming element of the camera. It is highly advantageous for the light source to be disposed within the camera lens assembly, as this allows a camera of conventional dimensions to be more readily used.

In an alternative arrangement, the light source may be a high intensity light source, and the key signal generated simply from the brightness of the signal alone, the brightness of light reflected from the background being arranged to be greater than that reflected from any of the subject. Use of brightness may be supplemented by detection of a particular colour or pattern or temporal frequency; this may alleviate problems caused by spurious extra bright areas of the subject, or less-bright regions of background.

The light projected onto the background may be made to vary with time. For example, the light may be flashed on or off (for example a strobe light),

and differences in brightness between scenes when the light is on and when it is off used to generate a key signal. This may be enhanced if a camera capable of imaging at a higher field rate than that required for the picture is used, extra fields being used to generate the key signal.

Motion compensation may be applied to align the key image better with the subject if extra fields are used, but a simple delay may be sufficient for many purposes. Alternatively, a temporally varying colour, for example alternately red and green may be used, the keying unit being arranged to detect areas which change colour between fields or frames. Where the subject includes actors, flashing light at certain frequencies (for example 25 Hz, and to a lesser extent 50 Hz) projected from the camera may be distracting; the effect of this can be alleviated by additional flashes during field blanking periods, or periods when the camera is not integrating, so that the light flashes at a less perceptable higher frequency; ideally the brightness level perceived by the subject should be substantially constant (excluding, of course, deliberate changes in set lighting).

Temporally varying illumination could be employed without a retro-reflective background, but a retro-reflective background greatly reduces the amount of light required, and so a smaller light source (e.g. an LED) which may be switched more readily at the frequencies required (of the order of 25, 50 or 100 Hz) may be used. The use of a temporally varying characteristic may enhance detection, and may enable a wider range of colours to be present in the subject than if a static colour were used for keying.

Referring now to Fig. 3, retro-reflective material, particularly suitable for use with the above embodiment will be described. Conventional retro-reflective material, as depicted schematically in Fig. 3a, comprises a backing sheet, typically of plastic material or cloth 20 having an adhesive coating in which glass balls 22 having a silvered hemisphere are embedded, the silvered hemispheres being fixed to the backing. This material works well when the

light is incident normally to the backing, or within a range of typically about 45 degrees of normal incidence. This material is therefore quite suitable for use as retro-reflective material when disposed substantially normal to the axis of the camera, for example on vertical walls (assuming the camera axis is substantially horizontal).

However, conventional material has poor retro-reflective properties at large angles of incidence, and hence may cause problems if used as a floor covering (with a horizontal camera axis). For example, for a typical studio with a camera at a height of 1 metre, the angle of incidence (relative to the normal) at the floor 6 metres away is about 80 degrees, and about 15 metres away is greater than 85 degrees.

Throughout this specification, incidence angle is defined assuming the retro-reflector means to be disposed on a planar surface, and measured with respect to the normal to that planar surface; an incidence angle of 90 degrees implies that the light is substantially parallel to the surface.

Referring to Fig. 3b, retro-reflective material according to another aspect of the invention is depicted. As can be seen, glass spheres 30 having approximately a hemisphere coated in reflective material 31 are disposed with a substantially random orientation on a backing surface 32, to which they are secured by a layer of adhesive 34. The backing surface is not smooth, but has hills and troughs of size comparable to the diameter of the spheres (the peak-to-peak amplitude of at least the largest undulations is preferably at least about half the mean particle diameter), so that when viewed from an oblique angle, a substantial proportion of the spheres are visible. This leads to substantially uniform reflectivity over a wide range of entrance angles. Although the absolute size of the spheres and undulations is not critical, it is desirable for the spheres to be substantially smaller than the resolution of the camera at all distances from the camera at which the material is to be located. In practice, the spheres have a diameter of significantly less than 1mm, typically of the order of 10-100 microns. With spheres of this size, another

advantage is that a cloth backing, for example, felt or the like, can provide a surface of suitable roughness. A thin layer of adhesive may be spray-coated onto the cloth or painted onto the cloth. As an alternative, thin flexible sheet adhesive, for example that available from 3M corporation under the trade name Scotch and supplied in rolls approximately 30cm wide for use in fixing photographs into albums may be conveniently used.

Although glass balls are convenient to use, other retro-reflective particles may be used, for example prisms comprising the corner of a cube, or other similar shapes. An advantage of substantially spherical particles is that they may be spread more easily and orientate themselves more randomly than particles with corners and flat surfaces. Suitable reflective spherical particles are available from 3M as part of their reflective ink kit 8010. These are intended to be embedded in an adhesive supplied with the ink kit and applied to a smooth surface as a reflective ink. However, the inventors have found that improved performance, particularly at large angles of incidence, is obtained if the particles are disposed on a separate adhesive layer.

A coating may be applied to the particles to retain them more firmly, and render the material more durable. However, it is important to ensure that the coating does not affect the optical properties of the material (typically this requires using a coating that is substantially transparent and of low refractive index), and preferably no coating is provided.

In a further development, it has been found that, in a retro-reflective material employing silvered reflective spheres (or other particles) improved properties are obtained if the outer surface of the spheres (the surface of other particles which does not contribute substantially to retro-reflectivity) is rendered less reflective (for example coated black). This reduces scatter from other light sources.

A comparison of the normalised gain of a conventional retro-reflective

sheet material (sold by 3M Corporation as reflective cloth 8925) and of a retro-reflective material according to the invention is shown in Fig. 4. From this it can be seen clearly that the invention provides more uniform reflectivity, particularly at large angles of incidence.

Normalised gain is defined as the gain (with respect to a white surface) at a given incidence angle divided by the gain at normal incidence. For a uniform material, the results should be substantially independent of the orientation and position at which the measurement is taken, but it will be appreciated that measurements need not be exact and that some variation in the properties of the material can be tolerated.

The conventional material had a higher peak reflectivity (typically about 5 times that of the material of the present embodiment), but for angles above about 50 degrees, the reflectance is much lower in relative terms, and in absolute terms is lower than that of the embodiment. In addition, the wide variation in relative terms is undesirable, as it can lead to unreliable keying, so little is gained by the increased reflectance at smaller incidence angles.

It may be desirable for the retro-reflectivity to be made to vary appreciably with material orientation as well as angle of incidence; in such a case, the material may be further characterised by a range of preferred orientations with respect to a light source. If complete characterisation is required a three-dimensional polar plot may be appropriate. It will be understood that if other factors, such as the curvature of the surface or the wavelength of light appreciably affect the material properties, these should be taken into account when using the material on a set.

A further embodiment of retro-reflective material, which has a maximum gain at an angle to normal incidence is shown schematically in Fig. 5. In this embodiment, substantially uniform silvered spheres 30' similar to those in the previous embodiment and in the conventional example are used as retro-reflective particles. The spheres are regularly disposed, as in the conventional

sample described above which on a conventional planar surface exhibits appreciable gain over a range of only about +/- 45 degrees to the normal. In this embodiment, however, the particles are disposed neither on a smooth surface nor on a randomly rough surface, but on a backing having a saw-tooth section, and providing a series of adjacent mini-surfaces 32' angled at about 45 degrees to the surface on which the material is disposed. This results in a peak gain at approximately 45 degrees to the normal to the underlying surface. The material exhibits substantial gain over a range of angles from 0 to almost 90 degrees when viewed from the "front", that is facing the mini-surfaces. The material has a substantially vertical rear surface, which is preferably black or otherwise absorbent to reduce scatter. Thus, the material exhibits little gain in the "reverse" direction. This is of little consequence when the material is used in its preferred orientations, on the floor of a set with the reverse direction facing the rear of the set. Preferably, a material which has an assymetrical gain pattern has a marking visible to the eye indicating a preferred orientation, the retro-reflective properties in the preferred direction being substantially unaffected by the marking. For example, a marking visible from the reverse direction or on the underside of the material may be used.

Numerous modifications will become apparent to those skilled in the art on consideration of the invention; the above embodiment is only an example.

For example, it would be possible to use a background "retro-reflective" material which reflects the majority of light at an offset to the incident light, for example in a cone around the incident light and offset the illumination relative to the camera appropriately, for example in a ring around the camera.

CLAIMS:

1. An imaging method comprising:

positioning a subject to be imaged between a retro-reflective background and camera means for acquiring an image of the subject;

illuminating at least the background within the field of view of the camera means from substantially the same direction as the camera so that light of a predetermined property is reflected to the camera;

processing the output of the camera to distinguish the subject from the background based on detection of the predetermined property.

2. A method according to claim 1, wherein the property includes colour or pattern.

3. A method according to claim 2, wherein the colour or pattern is projected onto said background.

4. A method according to claim 2 or claim 3, wherein the colour or pattern is incorporated in said background.

5. A method according to any preceding claim, wherein the property includes brightness.

6. A method according to any preceding claim, wherein the light projected onto the background varies with time according to a predetermined temporal characteristic, and the property includes the temporal characteristic of the light.

7. A method according to claim 6, wherein the colour or brightness, or both, of the projected light varies with time.

8. A method according to any preceding claim further comprising superimposing an image of the subject onto a further background to produce

The Patent Office

26

Application No:	GB 9701638.0	**Examiner:**	John Coules
Claims searched:	1-17,24-26,31 and 32	**Date of search:**	19 March 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4F FGJ,FGS,FGT

Int Cl (Ed.6): H04N 5/275,5/272,9/75

Other: Online: WPI,INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2297613 A	(SYNECTIX) see page 6 lines 19-22 and page 13 lines 2-17	31
X	GB 2162628 A	(APOGEE) see whole doc	1,10,11 and 31 at least
X	EP 0209317 A2	(RECOGNITION SYSTEMS) see page 6 line 13	1,10,11 and 31 at least
X	US 4471386	(XEROX) see retro-reflective marks 60,61	31

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
Y Document indicating lack of inventive step if combined with one or more other documents of same category.	P Document published on or after the declared priority date but before the filing date of this invention.
& Member of the same patent family	E Patent document published on or after, but with priority date earlier than, the filing date of this application.

a composite image.

9. A method according to any preceding claim comprising processing the image on the basis of the detected distinction between the subject and the background.

10. A method of providing a subject for imaging comprising providing a subject between a substantially retro-reflective background and a camera having, substantially coincident with optical axis thereof, a source of illumination of a predetermined key colour for illuminating said background.

11. Apparatus for imaging a subject, the apparatus comprising:

camera means for obtaining an image of the subject;

retro-reflector means for positioning behind the subject, as seen by the camera, for reflecting light originating substantially coincident with the camera back to the camera;

illuminating means associated with the camera means and arranged to project light onto at least said retro-reflector means within the field of view of the camera means to reflect light of a predetermined property back to the camera means;

processing means arranged to process the image to distinguish the subject from the background based on detection of the predetermined property.

12. Apparatus according to claim 11 wherein the retro-reflector means comprises a substantially flexible retro-reflective material.

13. Apparatus according to claim 11 or claim 12, wherein at least a portion of the retro-reflector means has a normalised gain of at least 1/4 at an incidence angle of at least 60 degrees, preferably at least about 80 degrees.

14. Apparatus according to any of claims 11 to 13, wherein the illuminating

means comprises at least one light source disposed near or around the camera.

15. Apparatus according to any of claims 11 to 13, wherein the illuminating means comprises a light source substantially optically coincident with the camera axis.

16. Apparatus according to claim 15, wherein the light source projects light through a lens of the camera used for forming the image.

17. Apparatus according to any of claims 14 to 16, wherein the light source comprises at least one LED.

18. A flexible sheet retro-reflective material exhibiting a normalised retro-reflectivity of at least about 1/4 at an angle of incidence of at least 60 degrees to normal.

19. A retro-reflective material according to claim 18 comprising a flexible sheet material coated with a plurality of retro-reflective particles, the particles being substantially randomly orientated on a surface of the material.

20. A retro-reflective material according to claim 19, wherein the particles have a reflective coating applied to a portion thereof, and wherein a surface of the reflective coating other than a portion which contributes substantially to retro-reflectivity is treated to inhibit scatter of light.

21. A flexible sheet retro-reflective material exhibiting retro-reflectivity at an angle other than normal incidence substantially greater than the retro-reflectivity at normal incidence.

22. An imaging method comprising:

positioning a subject to be imaged between a retro-reflective

background and camera means for acquiring an image of the subject;

illuminating at least the background within the field of view of the camera means from substantially the same direction as the camera so that light of a predetermined key colour or pattern, preferably colour, is reflected to the camera;

illuminating at least a portion of the subject from another direction, thereby to create a shadow on a portion of the background;

processing the output of the camera to distinguish the subject from the background based on detection of the predetermined key colour or pattern, wherein a measure of quality of key detection is determined based on the correlation between the output of the camera and the predetermined colour or pattern, and wherein the shadow portion is identified as corresponding to an area of the image in which the quality of key detection is greater than in surrounding areas of the image.

23. Image processing apparatus comprising:

means for inputting an image;

means for determining a measure of the presence of a key colour or pattern, preferably colour, in portions of the image, and detecting background regions of the image based on regions where the measure is above a threshold value; and

means arranged to identify background regions having a greater value of said measure as regions of shadow.

24. A camera for use in the method of claims 1 or 10, or the apparatus of claim 11, having an image forming-lens for forming an image of a subject on an imaging region and a light source for projecting substantially uniform light through the image forming lens towards the subject.

25. A camera according to claim 24, wherein the light source is located substantially in the focal plane of the camera.

26. A camera according to claim 24 or claim 25, wherein the light source is disposed within the lens assembly of the camera.

27. A method of imaging a subject comprising illuminating a background with light having a brightness or colour varying with time according to a predetermined temporal characteristic, imaging the subject and the background, and processing the image to distinguish the subject from the background based on detection of a temporal characteristic of the illumination.

28. A method according to claim 27, wherein the illumination received by the subject has a brightness which varies with time at a frequency greater than the frequency of variation used in detection of said temporal characteristic, or wherein the brightness perceived by the subject is substantially constant.

29. A method of imaging a subject comprising illuminating a background with light having a brightness substantially greater than a predetermined threshold, greater than the brightness of the subject, imaging the subject and the background, and processing the image to distinguish the subject from the background based on detection of brightness greater than said threshold.

30. Use of a temporally varying illumination characteristic to generate a key signal or to distinguish a subject image from a background image.

31. Use of a retro-reflective material to provide a background against which a subject can be distinguished based on the light reflected from the background.

32. A method of imaging a subject or apparatus for imaging a subject substantially as herein described, with reference to Fig. 2 of the accompanying drawings.

33. A retro-reflective material substantially as any one herein described,

with reference to or as illustrated in Figs. 3-5 of the accompanying drawings.